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Academic air travel has a limited influence on professional success

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ABSTRACT

Lowering the growth in greenhouse gas emissions from air travel may be critical for avoiding dangerous levels of climate change, and yet some individuals perceive frequent air travel to be critical to their professional success. Using a sample of 705 travellers at the University of British Columbia, we investigated the influence of career stage, research productivity, field of expertise, and other variables on academic air travel and the associated emissions. This is the first time that research has evaluated the link between observed air travel and academic success. First, we compared air travel behaviour at different career stages and found that individuals at the start of their careers were responsible for fewer emissions from air travel than senior academics. Second, since career advancement may depend on an academic's ability to form partnerships and disseminate their research abroad, we investigated the relationship between air travel emissions and publicly available bibliometric measurements. We found no relationship between air travel emissions and metrics of academic productivity including hIa (h-index adjusted for academic age and discipline). There was, however, a relationship between emissions and salary that remains significant even when controlling for seniority. Finally, based on the premise that academics studying topics related to sustainability may have greater responsibility or motivation to reduce their emissions, we coded 165 researchers in our sample as either "Green" or "Not-green." We found no significant difference between Green and Not-green academics in total air travel emissions, or in the types of emissions that might be easiest to avoid. Taken together, this preliminary evidence suggests that there may be opportunities, especially for academics who study topics related to climate and sustainability, to reduce their emissions from air travel while maintaining productive careers.

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1. Introduction

In recent decades, aviation has been one of the fastest growing sources of greenhouse gas pollution (Bows-Larkin and Anderson, 2013). Growth in air travel shows no signs of slowing, as the number of air travel passengers is projected to nearly double by 2036 (IATA, 2017). Meanwhile, technological developments in aviation are slow and unlikely to offset growth in demand, and neither governments nor the aviation industry has made significant progress in regulating the industry (Bows-Larkin et al., 2016). If the mitigation efforts of international aviation continue to underachieve compared to other sectors, the share of global carbon dioxide (CO_2) emissions for this sector could grow to 22% of the global carbon budget (Cames et al., 2015). Researchers have therefore claimed that reductions in demand for air travel may be necessary for meeting climate targets (Bows-Larkin, 2015; Girod et al., 2013).

Business is an important driver of air travel; for example, the World Tourism Organization finds that 13% of international trips are conducted for business or professional purposes (UNWTO, 2017). In person meetings are part of the culture of many industries, and travel is therefore believed to be key for professionals in maintaining the social networks that are associated with success (Urry, 2012). Kroesen (2013) conducted a survey of Dutch travellers, finding that 10% of the sample, who tended to be older, high-earning, frequent flyers, justified their air travel by the need to perform well at work, additionally stressing that there were no alternatives to flying. A study conducted at the Tyndall Centre for Climate Change Research found that half of respondents agreed that they flew to maintain and develop work relationships, and over 30% felt an expectation to fly from their university (Le Quéré et al., 2015).

While air travel for personal reasons can be highly discretionary – motivated by the desire to simply get away for a single weekend (Higham et al., 2014) or to tick destinations off a mental list of places visited (Randles and Mander, 2009) – professional travel

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may be more driven by perceived or actual necessity. In academia, international teams meet to coordinate their research, conferences host graduate students and lecturers, and field work involves flights to distant locations. Missing research or networking opportunities may reduce an academic's ability to collaborate, to publish frequent, high-impact research, or to maintain visibility in a field in order to be frequently cited (Storme et al., 2013). Indeed, internationally collaborative research results in publications with higher citation impact scores (Adams, 2013) and "mobile scholars" (those who change affiliations) have 40% higher citation rates than non-mobile scholars (Sugimoto et al., 2017). Efforts to mitigate greenhouse gas emissions from air travel may come into conflict not just with cultural norms of many professions and industries but could also interfere with the general efficacy of those industries. Yet to date, no studies have evaluated whether academic success is related to air travel.

One might expect that in a professional setting where climate change and sustainability are readily available subjects, individuals might be more cognizant of their carbon footprint and less likely to undertake polluting behaviours like air travel. This would certainly be the case for academics who study climate change, sustainability, and closely related topics. Indeed, there is additional motivation for such academics to track their carbon footprints: the size of a climate researcher's carbon footprint from air travel (specifically for work-related purposes like lectures and conferences) has been shown to affect their credibility in the eyes of the public (Attari et al., 2016). Furthermore, a ten-year study of English-speaking media coverage found that 32% of all accusations of hypocrisy levelled against pro-climate actors mentioned their flying behaviour – more than for luxury behaviours, driving, or diet (Gunster et al., 2018). Yet pro-environmental behaviours are contextually driven; individuals are more likely to undertake pro-environmental behaviours in their home than at a hotel, for instance (Baker et al., 2014; Miao and Wei, 2013). Balmford et al. (2017) investigated the carbon footprints of various academics, finding that conservationists fly substantially less than economists for work purposes and slightly less for personal purposes. It is difficult to know if this disparity between work behaviour and personal knowledge is caused by environmental values, or differences in work expectations between fields.

In this study, we examine the drivers of air travel behaviour at a large university using a unique database of air travel and publicly-available records on research productivity and compensation. Observed measurements have the advantage of avoiding failures in recall which often lead to underestimations in travel surveys (Clarke et al., 1981). Although other studies have used self-reported results to quantify the air travel behaviour of individuals or companies (Alcock et al., 2017; Andersson and Nässén, 2016; Balmford et al., 2017; Denstadli et al., 2013; Lu and Peeta, 2009), ours is the first that we are aware of to create an air travel emissions inventory and use it as a natural experiment. First, we assess the relationship between common measures of academic success (e.g., bibliometrics such as h-index, authors per publication, university salary) and emissions from air travel. Second, we classify academics as either "Green" or "Not-green" based on their areas of interest and then analyze differences between the two groups in travel behaviours, searching especially for differences in types of air travel that could be avoided with minimal effort on the part of the academic. By identifying the interests of academics spread through several departments, we aim to control for workplace norms and understand how personal motivations influence behaviour.

2. Materials and methods

For this study, we created a database of air travel undertaken over an 18-month period by travellers at the University of British Columbia (UBC). Ethics permission for the study was obtained from the UBC Behavioural Research Ethics Board. We contacted 26 academic departments, institutes, and faculties (henceforth referred to as units) representing the administrative homes of all faculty on UBC's Vancouver campus, eight of whom agreed to participate in our study. These units provided access to hard or soft copies of their travel requisition (TR) forms. From these forms, we entered the name (later anonymized), date, TR form number, cost, ticket class, length of trip (in number of overnight stays), airport codes, primary and secondary purpose, and additional information (number of flight segments) into the database. Trips were coded as Conference (e.g. conferences, workshops, group meetings), Fieldwork, Lecture (colloquiums etc.), University Business (board meetings, faculty searches) and Other. TR forms which did not include information on ticket class were assumed to be Economy class. We collected data on a total of 997 travellers taking 1769 trips. This study employs data for 705 of those travellers who were academics with identifiable positions (undergraduate students and guests with unknown affiliations were excluded).

2.1. Air travel emissions data

Greenhouse gas emissions per flight segment and per trip were computed following methods developed by the United Kingdom's Department for Business, Energy and Industrial Strategy (BEIS). The calculator uses CO_2 emissions factors for fuel burned in an average flight by representative aircraft with emissions allocated per passenger kilometer (pkm) based on average seating capacities and load factors (BEIS, 2016). Distance between the airports was calculated using greater circle distance and an 8% uplift factor was applied to account for additional distance travelled for holding patterns, etc., as recommended by the BEIS. Different factors are used for Economy, Economy Plus, Business, and First Class flights as higher class seating occupies more space aboard the aircraft and passengers in those seats can be considered responsible for a larger fraction of emissions (BEIS, 2016). The average quantity of greenhouse gases (measured in CO_2e, carbon dioxide equivalents) produced per pkm by domestic, short, and long haul flights, in the different classes, and accounting for average occupancy of the aircraft are shown below (Table 1). Finally, in our calculations, we include the radiative forcing multiplier of 1.9 to account for the additional net warming influence of high-altitude emissions (Lee et al., 2009). While some might choose to forgo this multiplier or even the 8% uplift factor, their inclusion in this study only affects the absolute reported values and not the findings of the study, which are based on comparisons within our sample.

2.2. Academic profiles

To test for the relationship between academic achievement and professional air travel emissions, we collected data on publicly available measures of professional success (salary, h-Index, and seniority within an institution) and on field of expertise for the UBC faculty, Research Associates, and Lecturers in the sample (data were available for 165 of the 208 faculty, Research Associates, and Lecturers [teaching faculty]).

Table 1
Emissions factors for different types of air travel ($kgCO_2e$/pkm).

Class	Economy	Economy Plus	Business	First
Short Haul	0.27867	0.27867	0.27867	0.27867
Medium Haul	0.16508	0.24761	0.24761	0.24761
Long Haul	0.14678	0.23484	0.42565	0.58711

Academics' salaries were retrieved from publicly available financial summaries which UBC publishes annually. Since salary increases with seniority, we created a new metric to separate these variables. Adjusted salary of individual *i*, measures salary increase per year and is calculated by subtracting the average starting salary for this sample (estimated by using the y-intercept of the linear regression for salary versus academic age) and dividing by academic age (number of years since first publication).

$$AS_i = \frac{S_i - 95013}{AA_i} \quad (1)$$

The h-index, a measure of the number of publications produced by a researcher and the number of citations those publications receive, was computed using Harzing's Publish or Perish Version 5 software, which retrieves bibliometric information on faculty from Google Scholar. We searched all faculty members listed on the departmental websites of departments that we sampled, first by searching their Google Scholar profiles. When no profile was available, we chose the name to search in the software from their publications list as shown on the website, e.g., "TM Jordan." Where a name was common, we disambiguated using the recommendations provided in the Publish or Perish software, and also added each institution at which the faculty member had worked or been a student when that information was available (found on UBC's website or the website Linkedin) under the advanced search function "Any of these words." Other possible measures of professional success or academic productivity, like number of research grants held, grant dollars received, and number of followers on Twitter, were not used here because data was not available for a sufficient fraction of the sample population.

Many metrics of academic productivity, including h-index, are highly correlated with career length, as well as the field in which they publish. To make comparisons between researchers in different career stages and in different fields, we therefore chose to use the hI, annual index, or hIa. The hIa can be calculated by taking the total number of citations for each paper divided by the number of authors on the paper, finding the h-index number of this normalized citation count, and then dividing by academic age (Harzing et al., 2014). The hIa is particularly sensitive to false positives generated when two different researchers share the same name, especially when very old publications are ascribed to a young researcher (thus giving them a substantially longer career length). We therefore sorted the list of publications by year and eliminated those published prior to the start of the faculty member's career in academia (as listed on their curriculum vitae or biography found on the UBC website). To further eliminate false positives, we searched the list of generated references for papers with titles that were dissimilar to the researcher's field of interest and for authors with names that were similar but not specified by search terms (e.g., when searching for "C Miller," Publish or Perish may produce false positives for "CJ Miller" or "TC Miller" which we excluded if they were not the author in question). Since h-index (and also hIa) removes the effect of a small number of seminal papers with a high number of citations, we also tested for relationships between travel behaviour and total citations (as well as citations normalized by academic age and authors per paper).

To test for the relationship between a faculty member's area of research and their professional air travel emissions, we coded each of the faculty members found in our sample into either a Green or Not-green academic classification. To do this, three raters read through the UBC profile of each faculty member present in our travel data, searching for one of eleven keywords (or variants of those keywords) which we anticipated would be associated with increased knowledge and concern for the climate impacts of aviation: sustain*, climat*, environment, greenh*, conserv*, biodivers*, ecosystem service*, carbon, renewable, green, and natur*. Identified keywords were ignored if the context of the keywords did not indicate further relevance. Searches were limited to a faculty member's area of research and teaching interest, which did not include a list of courses taught or a list of past or current projects. This method was employed to avoid false positives; for example, a statistics professor might collaborate on a climate project but not have any research interests in that particular field. Searches were also limited to UBC online profiles, unless the departmental website clearly indicated that the individual in question was a full-time instructor or academic and their interests were described on their own webpage. Faculty who did not meet these criteria (no available profile) were excluded from this analysis. The coding of all three raters was compared against each other (88% initial agreement, $n = 165$) and then the three raters discussed profiles where there was disagreement. Conflicting ratings were settled by further referencing other online information retrieved from a ResearchGate or LinkedIn profiles or a list of their publications.

Because data availability varied between the categories (e.g., a clinical instructor may have had salary information but no online profile and no bibliometric information), the maximum possible sample size varies between the different statistical tests that we conducted (Table 2). To maintain consistency, where possible, all tests were conducted on a core group of research academics for whom salary, bibliometric, and online profile information was available ($n = 128$), which we refer to as the Core Sample. The Green Profile sample contains a larger group of academics for whom online profile data was available to classify researchers as Green or Not-Green, but for whom bibliometric data may not be comparable (e.g. Research Associates). The Career Stage sample is used for analysis involving seniority and only includes Graduate Students, Postdoctoral Researchers, Assistant Professors, Associate Professors and Professors. To check for bias in our sample, we also collected information on the academic positions of 220 guests (whose air travel was paid for by UBC) by conducting online searches for their names (Guest Sample).

2.3. Statistical analyses

We used the collected data to test for relationships between travel behaviour, as measured by trips taken, distance travelled, and emissions produced, and the individual characteristics described in the academic profile. We analyzed relationships between variables first with t-tests, ANOVAs, and Spearman correlations. Student t-

Table 2
Demographic breakdown of the samples.

Group	n	Male	Female	Green	Not-green	Professor	Associate Professor	Assistant Professor	Other Employees[a]	Post-docs	Grad Students
Core Sample	128	83	45	49	79	74	30	15	9	N/A	N/A
Green Profile	165	105	60	63	102	77	35	18	35	N/A	N/A
Career Stage	450	N/A	N/A	N/A	N/A	78	35	20	N/A	59	258
Guest Sample	220	N/A	N/A	N/A	N/A	52	25	16	67	14	46

[a] Includes Deans, Adjunct Professors, Instructors, Research Associates, etc.

tests were used in cases of equal variance, but where F-tests showed unequal variance, Welch's t-tests were used. Welch's ANOVA was used for comparing data with unequal variance, followed by Games-Howell Post Hoc tests. We built OLS regression models to understand which variables were independent predictors of increased emissions or kilometers travelled. Breusch-Pagan tests were used to check for heteroskedasticity, and where $p < 0.05$ we conducted power transformations of the data. To avoid extensive trial and error, we identified the optimal exponent for transformation using the Box-Cox technique (Osborne, 2010). When investigating relationships between characteristics of researchers and binary outcome variables (such as whether faculty did or did not bill air travel during the assessed time period) logistic regression was performed and evaluated with repeated cross validation.

We tested for differences between Green and Not-green flyers by examining total emissions and also by searching for differences in specific types of flights that might be easily avoided (referred to here as "avoidable emissions"). These were flights that would require minimal effort to replace, including: brief trips (less than one or just a single overnight stay), brief but long distance trips (greater than 3700 km round trip but with only a single overnight stay), short trips that could reasonably be replaced by other modes of transportation (less than 312 km one way), and flights with higher class tickets (Economy Plus, Business, or First Class seats). Testing specifically for differences in "avoidable emissions" is important because the effect of these actions on total emissions of a flyer might be undetectable. For instance, a conscientious flyer might have a large emissions footprint because of long haul flights to attend a week-long conference or perform a month of field work, deemed by that person to be well worth the emissions, but may still take actions like substituting short distance flights with public transit or avoiding any non-economy class travel. We therefore tested for differences in total emissions in these avoidable categories as well as for differences in each individual category.

3. Results

Our collected data contains 1769 trips taken by 997 individual travellers from January 2015 to June 2016. These trips were responsible for 3018.81 tCO_2e. Two hundred and eight of the travellers were faculty, Research Associates, or Instructors in the eight units, and they were responsible for 47% of the total air travel emissions from the sample. Guests to UBC comprised 22% of all individuals in the sample and 41% of professors (assistant, associate, or full). Guest Professors were responsible for 82% fewer emissions (157.80 tCO_2e) than UBC Professors (882.00 tCO_2e) because the guests generally only had one trip billed to UBC.

This data allows trips to be classified by purpose and by category, like distance and length. Focusing on academic air travel (excluding trips by undergraduate students and administrative staff), the primary purpose of most trips was for conferences (60%), with the remainder attributed to fieldwork (16%), university business (6%), lectures (5%) or other miscellaneous and unreported purposes (13%). Air travel trips that could be categorized as avoidable – same day return, one night long-haul trips, or short distance – comprised 5–10% of all trips in the samples (Table 3). Some individuals also flew with tickets that were higher than economy class (e.g. business class). The number of trips that took place that were either avoidable, or where at least one leg of the journey was booked with higher class tickets comprised 16–26% of trips in these samples.

The greenhouse gas emissions per individual flyer increase with career stage in the sample (Fig. 1). According to Welch's ANOVA one-way test for unequal variance and Games-Howell post-hoc tests (which control for multiple comparisons of unequal size and variance), graduate students ($M = 2.44$ tCO_2e) and post-doctoral students ($M = 2.49$ tCO_2e) in the sample had lower mean emissions than Associate Professors ($M = 5.40$ tCO_2e) or Professors ($M = 7.52$ tCO_2e) ($p < 0.05$ and $p < 0.001$ respectively). Testing revealed no significant differences in emissions between genders when comparing within the group of Professors, Associate Professors, or Assistant Professors (data on gender of graduate students is incomplete). Logistic regression showed no statistical difference in the likelihood of researchers from differing career stages to take a trip in the avoidable emissions category or not. However, in terms of the quantity of emissions produced by travelling with higher class tickets, Welch's ANOVA showed significant differences between career stages ($F = 4.77$, $p = 0.001$), where Professors had greater emissions from purchasing higher class tickets than Postdoctoral Researchers or graduate students.

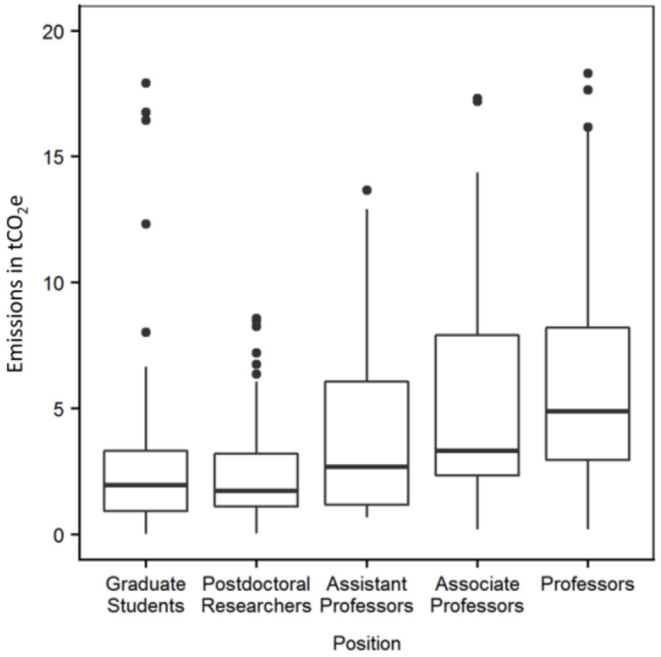

Fig. 1. Emissions of individual travellers grouped by career stage, n = 450. Note that some points beyond 20 tCO_2e are not visible here.

Table 3
Trips with avoidable emissions in the four samples.

Sample	Total Trips	Same day returns	>3700 km, one overnight	<312 km	Percent of avoidable trips[a]	Higher class tickets	Percent of trips with avoidable emissions
Core Sample	548	22	12	21	10%	87	26%
Green Profile	635	22	13	23	9%	101	25%
Career Stage	997	22	13	15	5%	111	16%
Guest Sample	248	5	10	5	8%	23	17%

[a] Percent of trips that are either same day returns, longer than 3700 km but with only one overnight, or less than 312 km in distance (and therefore replaceable by ground travel).

3.1. Metrics of academic performance

We found no statistically significant relationship in the Core Sample between the emissions from professional air travel of faculty members who flew during the time period of our sample and their h-index scores ($r_s = 0.13$, $p = 0.14$) (Fig. 2). While h-index is a popular metric for an author's productivity and citation impact, it is heavily influenced by academic age and by field of research, making hIa more appropriate for our purposes. There was also no correlation between hIa and emissions from professional air travel ($r_s = 0.04$, $p = 0.69$). When we compared academics at the same career stage (for instance, the 74 Professors in the Core Sample), the correlation between hIa and emissions was also not significant ($r_s = -0.10$, $p = 0.37$). Neither total citations, nor citations normalized by academic age and authors per paper had a correlation with trips taken, distance travelled, or emissions from air travel (see Fig. 2). Finally, we expected that increased air travel would allow for greater collaboration with other academics, and that there might be a relationship between the average number of authors per paper listed on a researcher's publications and their aviation emissions, but the correlation was not significant ($r_s = -0.05$, $p = 0.55$).

We repeated these tests using kilometers travelled, instead of emissions, to evaluate whether the use of different emissions factors for short, medium, and long haul air travel as well as different classes of tickets influenced the results. No relationships that were significant became not significant and vice versa using distance travelled as opposed to emissions (the correlation between distance travelled in kilometers and emissions produced is 0.99 for this sample).

Salary is correlated with emissions ($r_s = 0.29$, $p < 0.001$) in the Core Sample, but because salary increases with seniority, adjusted salary (or salary increase per year) is a more informative measure. Adjusted salary is also significantly correlated with emissions ($r_s = 0.28$, $p < 0.01$) (Fig. 3). We would expect to find that a university would compensate researchers who are more highly cited with greater salaries, and we do find that adjusted salary is positively correlated with hIa ($r_s = 0.41$, $p < 0.001$). There was no significant difference in mean adjusted salary between men and women in the Core Sample ($t = -1.70$, 95% CI [−912.94, 71.00], $p = 0.09$) or in the more homogenous sample of core Professors ($t = 0.20$, 95% CI [−482.49, 590.06], $p = 0.84$) (see Section 3.3).

To test whether the findings are affected by excluding faculty who did not travel by air, we repeated the analyses using a sample containing all full-time faculty listed on departmental websites

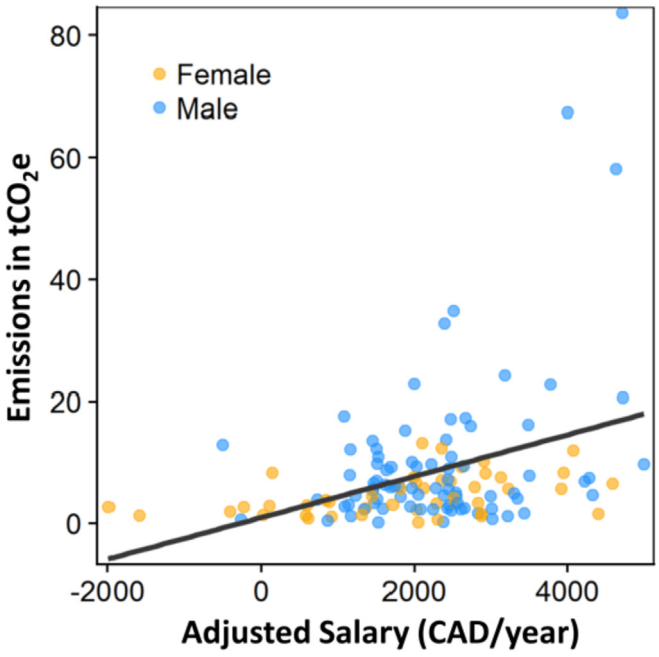

Fig. 3. Adjusted salary (salary increase per year) versus emissions generated by air travel for research faculty (Core Sample).

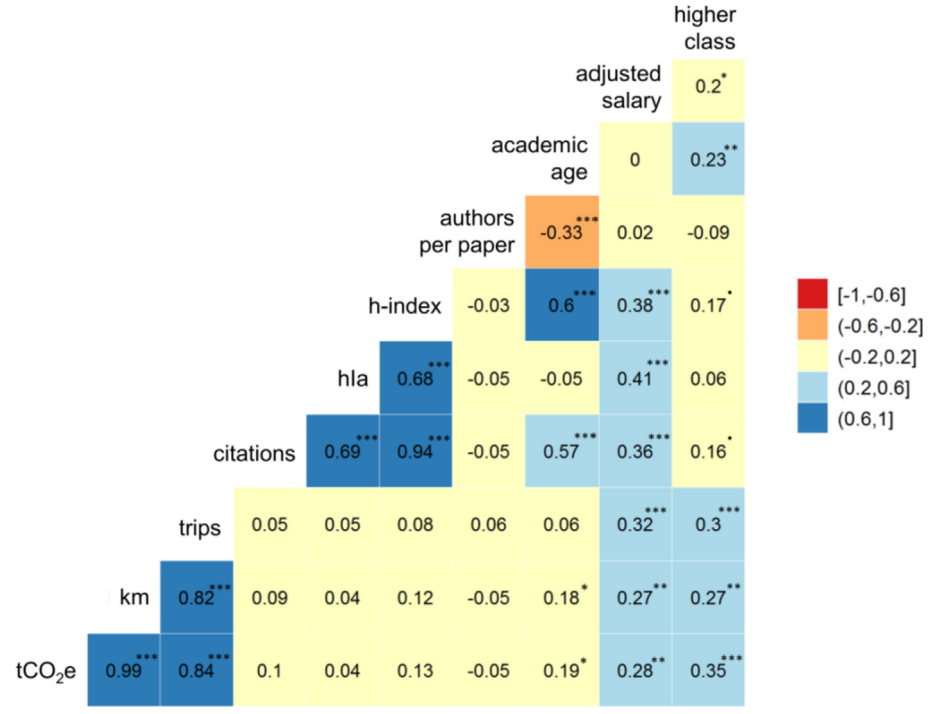

Fig. 2. Correlation matrix showing Spearman correlations; • indicates significance at the 10% level, * indicates significance at the 5% level, ** at the 1% level, *** at the 0.1% level.

(n = 188) which includes the travellers in the sample and the faculty who did not bill travel by air during the assessed time period. A larger fraction of male faculty (69%) than female faculty (66%) flew during the sample period, though this difference was not significant, χ^2 (1, N = 188) = 0.28, p = 0.597. A *t*-test showed significant differences in hIa between those who did fly (mean hIa = 0.79) and those who did not bill air travel during the period (mean hIa = 0.68, p = 0.047). Further analysis with logistic regression confirmed that hIa is significant in predicting whether a faculty member billed air travel during our sample time frame, including when controlling for academic unit and position.

3.2. Green flyers

Of the 165 academics with sufficient information to classify as Green or Not-green, 63 were classified as Green. Two of the units contained no Green academics, one unit contained only Green academics, and the remaining five units were mixed. Since this sample is quite diverse in terms of academic positions (including Lecturers, Adjuncts, Instructors, etc.), we report the results for the more homogenous Core Sample and confirm with the larger Green Profile sample. Travel behaviour as measured by emissions produced, distance travelled, or trips taken, was very similar between the Green and Not-green academics (Fig. 4). Mean emissions in the Core Sample (n = 128) for Green academics was 9.12 tCO_2e and 7.73 tCO_2e for the Not-green academics with no significant difference in means (Welch Two-sample *t*-test, 95% CI [-6.10, 3.30], p = 0.55). Mean distance travelled was 45,199 km for the Green academics and 46,310 km for the Not-green academics with no significant difference in means (Two-sample *t*-test, 95% CI [-16,742, 18,962], p = 0.90). Mean number of trips taken for Green academics was 4.39 and 4.20 for the Not-green flyers with no significant difference in means (Two-sample *t*-test, 95% CI [-1.64, 1.27], p = 0.80). Differences between Green and Not-green academics were also not significant for the larger group of 165 academics.

There was also no difference between Green faculty and Not-green faculty in the Core Sample for total avoidable emissions (t = −1.04, 95% CI [−3.74, 1.19], p = 0.30) or total avoidable trips (t = −0.14, 95% CI [-0.85, 0.74], p = 0.89). There were also no significant differences between the mean emissions for Green and Not-green flyers in any of the avoidable emissions categories (brief trips, brief but long distance trips, short trips, and flights with higher class tickets). This was true for both the Core Sample (n = 128) and the larger, Green Profile sample (n = 165).

3.3. Drivers of air travel behaviour

To better determine which of these variables is driving changes in emissions or kilometers travelled between individuals, we conducted linear regression analyses (Table 4). All models were heteroskedastic (with Breusch-Pagan Test, p > 0.05). We therefore used the Box Cox procedure to find appropriate exponents for transformations to achieve homoskedasticity. The best model incorporates career stage (position), salary, and academic unit (department) as predictor variables but still only explains 25% of the variance in the data.

While men in our sample produced significantly higher emissions than women (t = −3.4497, p < 0.001), this relationship was only marginally significant after controlling for salary and position (though the relationship was still significant for kilometers and for number of trips travelled). This may be explained by historical hiring practices which have resulted in men holding more senior positions (including both senior faculty positions and administrative positions such as Dean), both of which are associated with increased pay and increased emissions. Evidence of this can be seen in the salaries of these two groups; mean salary for men in our Core Sample was $162,083 and mean salary for women was $134,072 (t = −4.75, p < 0.001, df = 118.25), despite salary adjusted by academic age being similar in both groups. Furthermore, while only 28% of Professors in the Core Sample were female, 43% of Associate Professors and 67% of Assistant Professors were female.

Academic unit (department) had a significant influence on emissions when controlling for salary and position, suggesting that the departments in this sample have differing cultures or research needs that affect flying behaviour. Individuals with leadership roles in their unit (Deans, Assistant Deans, etc.) travelled substantially further than other positions, which is expected given their increased duties for the university. Adjusted salary was a significant predictor of emissions and kilometers travelled even while controlling for department, position, and gender. The hIa was not significant in predicting emissions or kilometers travelled in any model tested. Finally, models testing for the significance of h-index while controlling for department and position were also generated. This accomplishes approximately the same goal of using hIa instead of h-index since it controls for citing norms within a field as well as seniority. Neither models for CO_2 nor models for kilometers travelled (not shown) found h-index to be a significant predictor when controlling for department and position, as expected.

4. Discussion

Using a database of professional air travel at a major Canadian university, we found that emissions from air travel, distance, and number of flights taken were unrelated to academic productivity as measured by h-index (adjusted by academic age and discipline) or to an academic's area of interest (Green academics did not fly less than their counterparts). Instead, we found that academics who were further in their career and academics with higher salaries

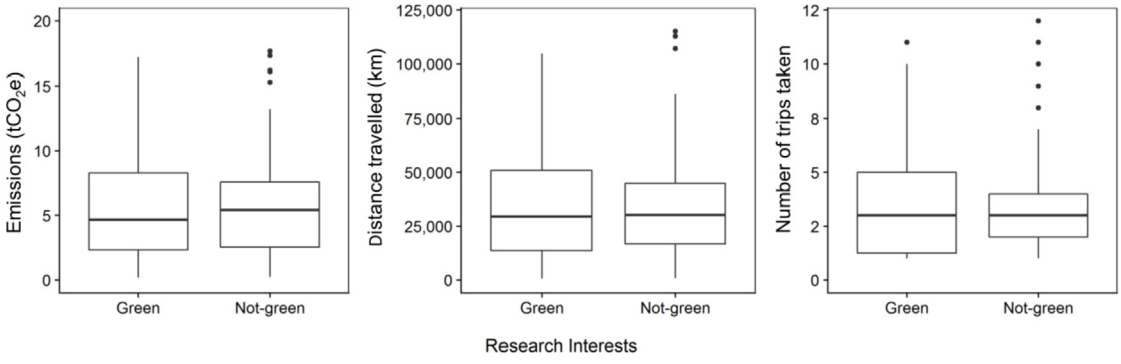

Fig. 4. Air travel behaviour of 128 research faculty in the Core Sample divided into "Green" or "Not-green" area of interest. Note that some values beyond the edge of the y-axis are not visible in each graph.

Table 4
Regression models predicting tCO_2e emitted from professional air travel.

	Model 1 ($tCO_2e^{0.15}$)	Model 2 ($tCO_2e^{0.15}$)	Model 3 ($tCO_2e^{0.15}$)	Model 4 ($tCO_2e^{0.15}$)	Model 5 ($tCO_2e^{0.15}$)
Assistant Professor	0.27 (0.41)	0.36 (0.40)	0.38 (0.41)	0.39 (0.41)	0.31 (0.41)
Professor	0.44• (0.26)	0.38 (0.26)	0.41 (0.26)	0.40 (0.26)	0.28 (0.27)
Dean	2.12*** (0.46)	1.99*** (0.46)	1.96*** (0.46)	1.96*** (0.46)	1.83*** (0.48)
Adjusted Salary	0.0003** (0.0001)	0.0003** (0.0001)	0.0003** (0.0001)	0.0003** (0.0001)	0.0003** (0.0001)
Gender (Male)		0.42• (0.23)	0.40• (0.23)	0.40• (0.23)	0.35 (0.23)
hIa			−0.23 (0.32)	−0.24 (0.32)	−0.06 (0.35)
Green (Yes)				−0.06 (0.22)	−0.39 (0.27)
Unit 1					−0.15 (0.33)
Unit 2					−0.06 (0.55)
Unit 3					−0.16 (0.59)
Unit 4					−0.58• (0.32)
Unit 5					−0.73* (0.34)
Adjusted r-squared	0.24	0.25	0.25	0.24	0.25
N	128	128	128	128	128

Standard errors are in parentheses. •indicates significance at the 10% level, * indicates significance at the 5% level, ** at the 1% level, *** at the 0.1% level.

took more trips and were responsible for greater emissions than their colleagues.

The fact that Green academics create similar emissions from professional air travel as the rest of the sample could be seen as further evidence supporting the knowledge-action gap, e.g., those who know more about the environment still do not adopt pro-environmental behaviours. Yet there are a number of alternative explanations for the similarities in behaviour between the two groups. First, it is possible that Green academics are more likely to conduct field work that requires more frequent and even more distant air travel (a researcher studying polar ecosystems may have more need of air travel for field work than a psychologist). Additionally, their fields of research may also be cutting edge and policy-relevant, and may therefore involve them in more international initiatives or committees (e.g., Intergovernmental Panel on Climate Change; Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services).

Such reasoning may explain overall differences, but not the lack of difference between the Green academics and the rest of the sample on easily avoided flights and purchases of higher class tickets. However, some academics may view the marginal effects of their own air travel as nil or negligible (based on the reasoning that their flight would occur whether they were on it or not). Certainly the feeling that one's own actions are nothing but a "drop in the ocean" is a commonly reported obstacle to motivating personal action on climate change (Hope et al., 2018; Lorenzoni et al., 2007). Others may not see a disconnect between their professional air travel and their area of research. Instead, professional air travel may be viewed as a useful tool that outweighs any environmental harm by enabling academics to collaborate effectively, communicate their findings, and contribute to solutions in global sustainability. For instance, defenders of Al Gore's air travel while filming and promoting *An Inconvenient Truth* suggest that the importance of his message compensates for his emissions from flying (Olson, 2007). The case of Gore's travel raises a more general problem – the fact that the air travel of climate researchers has been frequently used in ad hominem attacks on researchers, climate delegates, and environmentalists (Gavin and Marshall, 2011; Gunster et al., 2018).

Because increased air travel seems unrelated to academic productivity or collaboration, increased air travel may not be causing success (as measured by salary increase per year) in our sample. Instead, causation may operate in the opposite direction. Certainly, greater ambition or managerial skill may lead to promotions into administrative roles with higher salaries and more duties requiring air travel, as evidenced by the higher emissions of those in such roles in our sample. But the regression shows that adjusted salary is related to emissions even when controlling for seniority. Esteemed academics, with or without promotions, may be invited to deliver more lectures and have access to larger grants to afford frequent air travel (or purchase higher class tickets) and would also receive greater remuneration from their universities for the prestige they bring to the institution. Additionally, personality traits such as "niceness" and "demandingness" are related to a person's willingness to initiate salary negotiations (Bowles et al., 2007), and early negotiations over salary (whose outcomes are influenced by gender) can have large monetary consequences over a career (Gerhart and Rynes, 1991). The type of person who would successfully negotiate for a higher salary may be of the same personality that would request higher class air travel. For example, Canadian federal funding agencies do not allow for higher class air travel, and purchasing air travel tickets in a class higher than Economy at UBC requires permission of a senior administrator (Board of Governors, 2010). Andersson and Nässén (2016) similarly found a significant relationship between income and personal air travel, which is reasonable as those individuals with more income have more funds to afford it, and Balmford et al. (2017) found higher personal carbon footprints from academics who reported larger salaries.

These results highlight some of the interrelationships between salary, gender, and travel behaviour. Men travelled more than women in our sample, and even when controlling for salary, seniority, and department, men undertook more trips and travelled greater distances (though the difference in emissions between men and women was only marginally significant when controlling for other factors). This is consistent with past research showing that female academics are constrained in their ability to participate in sabbaticals abroad (Jöns, 2011) and generally have less mobile careers than male academics (Kulis and Sicotte, 2002).

We found some evidence that researchers who did not fly at all during the sample period may have lower academic productivity, though this relationship is not present in the samples where faculty took at least one trip by air. The results of this particular analysis should be interpreted with caution since some of the individuals may have no travel due to sabbaticals, parental leaves etc., while others may have flown but not billed expenses through the university. Still, the results do further suggest that some threshold of individual air travel may be necessary for success at a university (Storme et al., 2013) or for the success of research in general (Adams, 2013; Sugimoto et al., 2017), but the threshold is very likely below that of prolific flyers. The effect of increased collaboration on

knowledge creation (as measured by impact factor) has been shown to follow a pattern of diminishing returns, which may be explained by the opportunity cost of maintaining many professional relationships (McFadyen and Cannella Jr, 2004). A similar phenomenon may be at work here, where additional travel to share research or collaborate comes at the cost of time that could be used for research, grant writing, etc. The lack of relationship between hIa and emissions in the Core Sample (or trips taken or distance flown) could represent preliminary evidence that there is room for at least high-emitting academics to decrease their business air travel emissions without suffering negative consequences to their publication output. Indeed, academics at the beginning of their career who would arguably benefit most from air travel to establish their careers are actually flying the least in our sample. Green academics might be easily encouraged to "pick low-hanging fruit", such as not upgrading their travel tickets, in order to reduce their personal carbon footprints. Replacing higher class tickets with Economy tickets was found to be the most significant professional air travel mitigation measure at UBC, with the potential to reduce overall air travel emissions attributed to the university by 7.8% (Wynes and Donner, 2018).

It should be noted that our data does not capture all of the professional air travel conducted by the individuals in this sample. Those flights which are billed to other institutions (including for instance, guest lectures, government consultations, and job interviews) are not included in this dataset. If the flights for certain groups are disproportionately billed to offices outside of UBC then this may cause bias in our results. For instance, if senior Professors tend to accept multiple requests for talks at other institutions, then they may be flying more in total than what we present (assuming this is not offset by a similar amount of young academics attending job interviews, etc.). We found that guest Professors represented only 18% of all emissions from Professors. If other institutions invite guests at a similar rate to UBC then a simple extrapolation might suggest that our sample fails to capture approximately 18% of emissions from flights taken by faculty. We have no reason to suspect that flights paid for by other institutions would favour Green academics, but they do seem to favour senior travellers; there are far more Professors than Assistant Professors, and graduate students are greatly underrepresented in the guest sample (see Table 2). While this indicates a limitation of our study, it is perhaps unavoidable if our research questions are to be answered without self-reported results.

Our data also represents an eighteen-month window in time which limits our ability to understand success over the course of an individual's career. Present travel behaviour may be a good indicator of past travel behaviour; other forms of mobility are very habitual (Moser et al., 2018; Verplanken et al., 2008). This might also be the case for academic air travel, where researchers make a habit of travelling to certain conferences by air every year. Ideally, future research exploring air travel behaviour would include longitudinal data so that causation could be established.

The study findings could also be influenced by the chosen setting and the available metrics of academic productivity. UBC is an environmentally progressive institution, meaning there may be a narrower gap in personal beliefs or environmental knowledge between the Green and Not-green groupings than at other institutions. Although we found no relationship between authors per paper and emissions, this is perhaps a weak indicator of academic collaboration and should be taken with a grain of salt, as it is likely to be highly influenced by norms in a field. The h-index and hIa are more reasonable measures for academic success; regardless of their flaws (Bornmann and Marx, 2011) and criticisms of their effect on academic culture (Lawrence, 2008), such measures of scholarly output are frequently used in hiring or grant funding decisions and are moderately but significantly correlated with salary in our sample (Fig. 2). Future research could measure academic success in numerous other ways (public outreach, patent applications, grant funding, number of students supervised, etc.), but when investigating the claim that air travel is an unavoidable workplace expectation, and may be necessary to garner increased standing in the field, the indicators employed in this study are highly relevant.

Our findings are potentially meaningful for institutions considering ways to decrease their air travel. Possible initiatives might include an internal cap and trade program, offsets or mitigation charges (Menton, 2018), regulations, etc. Since 26% of trips for core faculty were associated with what we categorized as avoidable emissions, and since senior researchers fly considerably more than junior researchers, some senior researchers can likely reduce their air travel without a measurable impact on their scholarly productivity. Conversely, graduate students and Postdoctoral Researchers seeking faculty positions may have less flexibility to reduce their air travel without making career sacrifices. For institutions, these initial results suggest that an overall reduction in air travel, assuming that it still allows for a base level of mobility and does not penalize populations that already fly infrequently, may be feasible without affecting the productivity of the institution.

These results add to a nascent area of research showing the potential for leadership through reducing excess air travel. Because climate messengers are viewed as more reliable if they fly less (Attari et al., 2016) and because early evidence suggests that those who fly less influence the attitudes, choices and policy preferences of those who know them (Murray, 2019; Westlake, 2017), academic air travel has consequences beyond the emissions of those actually flying. Millions of students each year will be introduced to societal norms regarding professional behaviour through universities, and so a university culture that endorses prolific air travel will make public acceptance of policies that curtail air travel and promote videoconferencing that much more difficult to implement. Our results are therefore potentially relevant for climate leaders, other scientists, and academics across the world.

5. Conclusions

Drawing from a sample of 705 travellers at UBC, we investigated the relationship between academic achievement, research interests, and emissions from air travel. To our knowledge, this is the first time that observational data has been used to test the relationship between professional success and air travel. We found no relationship between academic productivity (as measured by h-index adjusted for academic age and discipline) and emissions from air travel. Although university salary was related to emissions, the direction of causation could not be firmly established. Finally, we found no difference between the travel behaviour of Green and Not-green academics, even in categories of emissions that might be avoided with minimal effort, such as upgrading to First Class air travel. We conclude that academics, especially Green academics with professional incentives to fly less, may be able to reduce their air travel emissions without making significant career sacrifices and thereby act as cultural leaders.

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